Interdisciplinary Research Program

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LONG-TERM GOALS

The long-term goals of this program are to foster interdisciplinary research efforts which combine the research interests of several investigators. In addition, the ARL Program provides partial Laboratory support for post-doctoral students and new academic appointments.

RESEARCH COMPONENTS

Investigation of Ocean Sound Speed Variations in GPS-Acoustic Measurements with FLIP (D. Chadwell, F. Spiess, and J. Hildebrand).

The objective of this project is to investigate the impact of ocean sound speed variations on Global Positioning System-Acoustic (GPS-A) measurements by observing contemporaneous acoustic transmissions to seafloor transponders both from a surface buoy and from 90 m below the surface from a FLIP-mounted transducer. This configuration allowed us to separate near-surface ocean sound speed variations from the more stable environment below and assess the impact that the near-surface ocean sound speed variations have on the precision of the GPS-A technique. Sixteen hours of contemporaneous GPS-A data were collected from both the buoy and FLIP on 6 June 1999 in 1000-m deep water offshore San Diego. The GPS and acoustic data have been processed and merged to produce GPS-A data residuals which contain signatures of the sound speed fluctuations. Preliminary results suggests that indeed the deeper FLIP transducer does reduce the impact of sound speed fluctuations compared to a near-surface transducer, but that data spans of several hours collected from the surface-mounted transducer can achieve similar results. Thus, GPS-A data can be collected from either buoy or ship-mounted transducers.

The Influence of El Niño on Ocean Mixing (R. Pinkel)

The focus of this project is to observe how the changes associated with El Niño modulate ocean-mixing rates near coastal topography. High frequency sound propagation is sensitive to the presence of ocean turbulence. While a fairly clear picture of the occurrence of turbulence in the open ocean is emerging, studies in coastal regions are just being initiated. To study the phenomenology of coastal turbulence (while monitoring HF acoustic scattering from Doppler sonars), the research platform FLIP was moored at a site where energetic mixing was suspected. An extensive series of ocean density and velocity profiles were collected during August-September 1998, while FLIP was anchored at the crest of a seamount on the continental borderland. The site proved to be extremely energetic with internal

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tides in excess of 70 m observed, along with numerous breaking internal waves. Initial analysis of this data has shown that the energy levels of many small-scale phenomena appear to be modulated at tidal frequencies. The tide itself does not have the ray-like character expected near a generation site. It is strongly dominated by the first vertical mode, even directly over the generating seamount.

Acoustics, the Afternoon Effect, and Climate Change (R. Pinkel)

The purpose of this project is to develop an inexpensive, vertically profiling oceanographic float which will provide a platform by which single sensors can be used to measure at a variety of depths in a repeated fashion. This capability is particularly important near the sea surface, where afternoon heating greatly alters the temperature and sound speed structure on a regular basis. Our approach is to design a positively buoyant profiler, the "Wirewalker", which traverses a 3/8" wire that is suspended from a small surface float. Wave action on the float causes the wire to oscillate vertically. A cam in the profiler rectifies this motion, pulling the profiler down the wire. At the end of the wire, the cam is disengaged and the profiler floats vertically to the surface. At this point it is uncoupled from the mooring and can sample the ocean undisturbed by the violent motions which accompany most surface moorings. A prototype Wirewalker was developed by graduate student Luc Rainville. Following nearshore tests from small boats, the profiler was deployed from FLIP during a September 1999 cruise. After initial tuning, a long series of profiles was collected from the surface to 60 m. A Seabird Temperature-Pressure recorder documented the Wirewalker's trajectory. It was found that the instrument could complete a 60 m profile every 15 minutes in typical conditions. In a glassy (open ocean) calm, the trip took as long as a half-hour.

HF Acoustic Backscatter from Ocean Surface and Bubble Clouds (J. Smith and R. Pinkel)

The objective of this project is to explore some time-space coherence characteristics of HF acoustic backscatter (in the vicinity of 200 kHz) from the near-surface bubble clouds produced by breaking waves. To this end, a "phased-array Doppler sonar" (PADS) system was deployed at 14 m mean depth from R/P FLIP, with the center-beam aimed directly upward from about 4 m stand-off distance (mounted on the outside rim of the thruster tower on FLIP's hull). The plane of the imaged sector was aligned roughly with the wave propagation direction, so the imaged area is a vertical "slice" capturing the vertical and along-wave directions. At 52 "pings" per second, there is sufficient intensity feature coherence from ping to ping to track unambiguously smaller "bubble-cloudlets," and there is even enough acoustic phase coherence to encourage closer examination of the phase evolution (e.g., Doppler shift?) from one ping to the next. Simultaneous video imaging will facilitate qualitative comparisons between the depth and density of bubble clouds with the perceived "strength" of breaking. Waves with heights up to about 4 m were observed over the three weeks of the experiment (9-27 September 1999), with direct plume penetrations observed to about 1.5 m depth.

Acoustic Backscatter and Bathymetry Along 3500 km of Murray Fracture Zone (P. Lonsdale)

The purpose of this research is to use a modern multibeam sonar to determine the structural geomorphology of one of the major North Pacific fracture zones, and to test whether along-strike variations in structure could be explained by small changes in the direction of relative plate motion at the transform fault that created this fracture zone between 85 and 25 million years ago. The history of these changes had been interpreted from previous ONR-funded geophysical surveys. Data collection with a Seabeam 2000 sonar (and ancillary gravimeter and magnetometer) was conducted on a transit of R/V MELVILLE across the North Pacific between San Diego and Majuro in January 1999; most data

processing was accomplished aboard ship. The ~20 km-wide swath of high-resolution bathymetry and backscatter imagery provides the first complete coverage along a Pacific fracture zone, and reveals dramatic variations in structure, dependent mostly on whether the generating transform fault was in a transpressive mode (i.e., with a component of compression across the strike-slip fault) or a transtensional mode (with a component of extension). In the former case, large intensely sheared ridges up to 3 km high were squeezed up, and survive along the fracture zone. With transtension, deep rift valleys opened up, but they are bounded by uplifted rift shoulders that with low-resolution data (e.g.,satellite altimetry or wide-beam echo-sounders) are difficult to distinguish from the compressional ridges, though they are very different in structure and composition. The improved understanding of the structure of this "typical" fracture zone, and of the factors that cause it to vary, is applicable to fracture zones throughout the Pacific basin. In particular, the results help explain previously puzzling variations in the gravitational signatures and the exposed rock types of these features, and suggest which locations should be targeted for more intensive studies.

Bubble Formation Mechanisms and Ambient Noise Production in the Open Ocean (G. Deane)

The objective of this project is to obtain simultaneous measurements of bubble size distributions and ambient noise from open-ocean whitecaps. The overall goal is to develop a detailed understanding of the connection between surface wave activity and ambient noise generation. An optical instrument to measure the numbers and sizes of bubbles within white caps was attached to a surface-following mount along with two broad-band hydrophones to measure breaking wave noise intensity and coherence. The surface-following mount maintained the instruments within 0.5 m of the ocean surface throughout the deployment, which took place 100 miles due west of Point Loma, San Diego during the period 5-11 April 1999. The instruments were tethered to one of FLIP's booms and monitored with a surface video camera. Wave height and meteorological data were recorded throughout the 6 day deployment. A single storm event was encountered, providing 40 knot winds and significant surface wave activity. Measurements of the bubble size distribution within open-ocean white caps were obtained, along with simultaneous measurements of breaking wave noise. The bubble size distributions show significant numbers of large bubbles which have important implications for low frequency ambient noise generation and bubble-mediated, air-sea gas transfer. High quality acoustical recordings were difficult to achieve on the surface-following mount, but a sufficient number of breaking wave events were captured to begin a combined ambient noise, bubble size distribution analysis. David Farmer and Svein Vagle from IOS participated on the cruise and deployed acoustical resonators and coherent Doppler sonars providing bubble size distribution measurements that complemented the SIO data.

Low-Cost Acoustic/GPS Drifter Technology (E. Terrill and K. Melville)

The focus of this project is to develop a Lagrangian surface drifter which will enable environmental monitoring using acoustical and conventional techniques. Two prototype drifters currently are being constructed and are scheduled for field testing offshore La Jolla in early 2000. The field testing of the unit is planned to coincide with rough winter conditions to provide insight into the relationship between surface wave breaking and ambient noise variability in the 500-20 kHz band. The buoy's surface package houses a data acquisition unit designed for the measurement of sea-surface temperature, barometric pressure, and wave height and spectra (measured using an on-board motion package). The buoy's drift velocity and position will be measured using an onboard GPS receiver. Acoustic data will be obtained with the calibrated ITC 1032 hydrophone that is suspended beneath the buoy’s drogue at a depth of 10m. An onboard DSP system using a Motorola chip is currently under

development to provide for onboard processing of the signal. Acoustic data will be stored on PCMIA flash memory. During the field testing component of the program, we anticipate testing a moored version of the drifter which would allow rapid deployment of the system from a small boat in water depths up to 100m.

Undergraduate Summer Insternship (J. Hildebrand)

A summer undergraduate internship component of the ARL program was established in FY97 with the objective of introducing undergraduates to oceanographic research relevant to the Navy. In FY99, seven undergraduates were selected from a number of applicants across the country and they spent 10 weeks in residence at SIO working with MPL research groups.